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## SOME ECOLOGIC RELATIONS OF THE POTATO AND ITS CHIEF FUNGOUS PARASITE, *PHYTOPHTHORA INFESTANS*

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It is the purpose of the present article to present results of experiments as well as a variety of observations which relate to the development of the disease known as late blight. No attempt is made to go over old ground. Some of the better known facts are mentioned briefly but only as they are concerned in rounding out the general picture. The references to previous work are by no means complete and in many cases other work might have been cited with equal propriety.

### EFFECT OF INTERNAL CONDITIONS ON SUSCEPTIBILITY OF THE POTATO PLANT

"The immediate cause of the potato disease is sudden and extreme alterations of weather, occurring at critical periods in the growth of that plant." This quotation from Goodrich (9) was published 12 years before the cause of potato late blight was known and at a time when practically the entire scientific world was agreed that the fungus which could be found on diseased leaves was a result of disease and not the cause of it. Until his death in 1864 Goodrich never admitted the causal relation of *Phytophthora infestans* to the disease but concerned himself more with the "remote cause," namely "the exhausted energy of nearly the whole species cultivated in Europe and the United States." His observations regarding the "immediate cause"

of the disease, however, are in line with recent investigations on the biology of *Phytophthora infestans*. Goodrich, of course, directed his attention to the effect of weather conditions upon the growth and development of the potato plant. The idea that there are "critical periods in the growth of that plant" with reference to the occurrence of blight is held at the present time by a great many persons. Two such periods commonly singled out as particularly critical are the period of rapid tuber production (Jones and many others) and, the date of maturity (Müller and others). Goodrich's own data for Utica, New York coupled with observations of recent years made in substantially the same locality (Ithaca, New York) are the best refutation of his contention, as they are also perhaps of those who adhere to the belief that there are critical periods with reference to blight susceptibility in the development of potato plants. "On the nights of July 4 and 5, 1846 potato plants," Goodrich (9) writes, were subjected to "a severe chill" with temperature of 40° and 45° F. The unseasonably cool weather continued for 10 days, for Goodrich adds: "Eight days after the cessation of the chill, i.e. on the 24th of July, the first indications of the disease were seen." In 1847 the low temperature of 40° and 50° F. occurred on the nights of July 28 and 30. Goodrich predicted an outbreak of blight and "it came overwhelmingly" appearing about the middle of August. The observations of Stewart et al (21) made in the decade 1902 to 1911 indicate likewise that the first occurrence of late blight is not dependent on the age of the plants. During this decade the first appearance of blight at Geneva, N. Y. varied from July 15 to September 29 and in 3 years was not found at all. In contrast with these records of relatively early appearance of blight, it is to be noted that in the past 20 years (observations of F. C. Stewart, M. F. Barrus, Charles Chupp and a large number of agricultural agents, inspectors and others) the outbreaks of blight in central New York have not assumed serious proportions until some time in September. Pethybridge (17) planted potato tubers at regular intervals throughout the growing season and observed that the disease spread naturally through the entire planting regardless of the stage of development of the plants. Identical results were obtained at Ithaca in a repetition of the Pethybridge experiment. Both early and late varieties were included in the trials in order to overcome in so far as might be possible the effect of length of day on the inherent conditions of the potato. The field trials were duplicated in the greenhouse with potted plants and inoculated under identical conditions. No difference in susceptibility was observed on the plants,

some of which were just through the ground, others large and vigorous and still others fully mature or even senile. Finally, with the thought that an immune plant might be so weakened in its resistance at some "critical stage" in its development that it would break down and become somewhat susceptible to blight, *Solanum demissum* Lindl. has been inoculated repeatedly at all stages in its development from tiny seedlings with only two cotyledonary leaves to fully mature plants but no lesions have ever been produced. The work has been done in the greenhouse because this species does not begin tuber formation until approximately the time of the autumnal equinox and at a time when air temperature is too low for trials in the open. In view of all these circumstances it does not appear that inherent characteristics of the potato plant are responsible for the occurrence or severity of blight at any particular stage in its development.

#### EFFECT OF EXTERNAL CONDITIONS ON SUSCEPTIBILITY

Turning now to the effect of external conditions as they affect the susceptibility of potatoes to blight the most obvious thing observable is the dearth of information on the subject. Some fairly extensive work along this line has been reported by Crosier (8). Briefly, it may be said that potato plants grown under a variety of external conditions, when inoculated with a viable culture of *Phytophthora infestans* showed no appreciable differences in susceptibility. Water content of the soil, in particular, did not alter the susceptibility of the plants in any observable way. It does not appear from work thus far done that any external condition which affects the development of the potato plant alters its susceptibility. All observations to the present time have had to be made with susceptible plants so that possible effects must appear as increases in resistance. It may be, now that immune and highly resistant plants are available for study, that decreases in resistance under different environments can be demonstrated. This, however, remains to be shown.

#### EFFECTS OF EXTERNAL CONDITIONS ON INFECTION

It is well known that external conditions influence enormously the prevalence of blight during a season or in a particular locality, and, since it has not been demonstrated that this influence relates in any way to the host plant, it has to be assumed that it relates to the parasite.

*Moisture.* Numerous attempts have been made to correlate blight outbreaks with weather conditions of the growing season. Lutman (12), for example, finds that in general "blight years" correspond with years of high precipitation during the growing season. He notes certain exceptions, however, and it is to these exceptions that attention should be directed. In confirmation of these exceptions Reddick (19) observed a steady and constantly increasing spread of blight in a plot at Ithaca, N. Y. in 1928, a growing season of low rainfall, with the disease spreading during a period when there was no measurable precipitation. This led him to conclude that, once the organism causing blight gets to the foliage, the important considerations in the spread of the disease are proper humidity conditions coupled with sufficiently frequent low temperatures to bring about germination of the sporangia. He explains the numerous positive correlations of high rainfall and blight years on the assumption that in a rainy season the high humidities necessary for sporulation would occur more frequently than in a dry season, and likewise that the cool weather which usually follows cyclonic storms would furnish more frequent low temperature conditions upon which sporangium germination depends.

The attempts of Coons (6), Martin (13), Gratz (10) and others to correlate epiphytotics of late blight with heavy precipitation, especially during July may be explained in the same way. The important exception to be noted in all these cases is that heavy precipitation at any time during the growing season would be favorable to, and perhaps even necessary for, the migration of the fungus from the diseased seed piece to the foliage. Certainly the chances for such migration would be greatly improved. *Phytophthora infestans* has been found by Murphy and M'Kay (16) vegetating in the soil about diseased seed-pieces and Miss De Bruyn (4) has grown the fungus in various kinds of sterilized soils for long periods of time. A very dry surface layer of soil, however, would practically preclude the spread of the fungus to the leaves that might touch the ground.

Although the prevailing opinion is that the fungus migrates through the soil and reaches the foliage by way of the leaves that touch the ground, or those covered by cultivation or by washing rains, as has been emphasized by Clinton (5), the spread of the fungus up the new shoots either directly from the seed-piece or by reinfection is a known phenomenon and it is possible that this method is of sufficiently frequent occurrence to establish the fungus above ground. In the latter event high soil moisture would not be a necessary

concomitant and the blight could become serious even in a season of subnormal rainfall.

*Temperature.* Following the pioneer work of Melhus (15) it is known that low temperature is an important factor in the spread of blight and this is coming to be generally recognized although a surprisingly large number of potato growers still cling to the "hot and muggy" idea. The rôle of high temperature on the other hand in the suppression of blight has not received as much consideration as the initial observations of Jensen warrant giving it. Jensen records (11) that the mycelium of *Phytophthora infestans* was killed although the viability of the tubers was not affected by baking affected tubers for four hours at an approximate oven temperature of 40° C. (Maximum temperature attained in any trial 46.2° C.) Thermometric readings at a depth of 1 cm. in the tuber showed that at the end of 4 hours the temperature at that point was 34.4° C. The exact thermal deathpoint of the fungus in tubers seems not to have been determined. McAlpine (14) reports that a slice of a diseased tuber incubated for 4 hours at 43° in dry air subsequently produced a fine growth of the fungus. The records of Vowinckle (23), on the other hand, show that at 30.3° the fungus had grown only 4 mm. in an inoculated tuber after 13 days incubation and growth curves constructed from his data suggest that the upper critical temperature is being approached rapidly. Crosier's experience (8) with pure cultures of the fungus on potato-dextrose agar suggest the same thing for at 35° he found no growth whatever; at 30° scarcely more growth than might be accounted for by the lag in bringing the culture dish up to the temperature of the incubator; and even at 26° his cultures died after about 10 days.

A time-temperature curve for the thermal death-point of *P. infestans* comparable to the one constructed by Blodgett (1) for the thermal death-point of potato tubers is needed. This requires an ample supply of naturally-infected tubers, something that has not been readily available for the past several years. Limited trials made recently show that the fungus is alive in tubers that have been treated for 4 hours in a dry-air oven or in a water bath at 36° C. After 7 hours at 36°, the parasite is alive in ovenized tubers but not in those subjected to moist heat. Limited tests at 39° show the fungus to be alive after two hours incubation but not after 4 or 7 hours. This pushes the thermal death-point somewhat higher than had been previously indicated (excepting the single case reported by MacAlpine) but again emphasizes the need of a time-temperature curve as well

as a record of the effect of intermittent heat treatments. The following experiments were made on the presumption that the thermal death-point is more nearly that determined by Jensen and do not represent conditions that would have been chosen in the light of present knowledge. The observations are based on natural conditions. Both contribute something to an understanding of what is going on in the potato field.

Potato plants in pots were inoculated on the leaves and when lesions appeared the plants were placed in a constant temperature chamber and held there at 30° C. (86° F.) for 6 days. The lesions increased in size from day to day. Other plants with lesions on the stems were subjected to a constant temperature of 35° C. (95° F.) for 9 hours and still others were "baked" at 40° C. (104° F.) for 4 hours and then all were removed to a chamber held at approximately 20°. Living mycelium was found in these stems a few weeks later.

A less exact test consisted in exposing inoculated plants to the uncontrolled temperature of an unshaded greenhouse in July 1931. In one set of observations the temperature of the house was 33° C. (91° F.) for several hours each day and reached 43° C. (110° F.) during the hottest part of the day. Subsequent examination of lesions on small stems of these plants showed that of the 197 lesions examined, living mycelium was present in 1 lesion only. In another case, lesions near the base of larger stems (7 to 13 mm. in diameter) were exposed for 30 days to temperatures, on most of the day, approximately those just mentioned, at the end of which time living mycelium was found in several of the lesions. In all these cases the night temperature dropped to approximately 21° C. (70° F.). It is likely that the temperature in these larger stems lagged behind that of the surrounding air and that the mycelium was not actually subjected to the temperatures mentioned.

The observations were next extended to the field. Early September 1931 brought conditions favorable for natural infection. In the Tioughnioga Valley, located about 10 miles from Ithaca, potato blight is likely to be found every year, at least to a limited extent. On September 16, 1931, following the excessively hot (at times) and dry months of July and August (in July there were 13 days, and in August, 10 days with temperature of 30° C. or higher. The precipitation in July was 2.73 inches, compared with 3.54 normal; and in August 1.3 inches, compared with 3.39 normal) the blight was found abundantly in an unsprayed field in this valley. This had been made possible because on the night of August 30 and every succeeding night until September 8 the temperature approximated the optimum for



germination of sporangia, and in addition there was a heavy rain on September 2 (1.3 inches) with at least a trace of rain on the 3 successive days. Beginning September 9 the maximum temperatures at Ithaca were as follows: 35, 37, 37, 38, 33, 32° C. The thermometer stood at 30° or above for these respective days for the following number of hours: 7, 9, 9, 10, 9, 5. Believing that such a set of conditions would furnish a good test of the killing effect of high temperature on the fungus, affected leaves from different parts of plants were placed in moist chambers suitable for bringing up fructification of the fungus. Of the 323 separate leaves examined 47 (14 per cent.) developed sporangia. In affected leaves taken from the upper part of plants 7.6 per cent. contained living mycelium, but the fungus was alive in 57 per cent. of the shaded leaves taken from near the ground.

The above temperature records were obtained from the Ithaca station of the U. S. Weather Bureau and are for shade. There are no records available for determining what temperatures may have been reached in direct sunlight in this field. It is obvious, on the one hand, that the fungus was not completely eradicated from this field by intermittent heat treatments of 30° and above for at least 7 hours on 5 successive days; and, on the other hand it is evident that such conditions killed about 86 per cent of the fungi present. This estimate is based on the common experience that under ordinary conditions every lesion on leaves placed under suitable surroundings develops fructifications of *P. infestans*.

*Humidity.* In his paper of 1928, Reddick (19) refers to humidity but only in its relation to the maintenance of a film of water on the foliage to permit swarm-spore formation and germ-tube penetration. Szymanek (22) appreciates the relation of high humidity to sporulation of the fungus. Summarizing very briefly from the controlled experiments of Crosier (7, 8) it may be said that at Ithaca a relative humidity of 95 per cent. or higher over a period of about 8 hours has been found necessary for fructification. Furthermore, sporangia lose their viability very rapidly when relative humidity drops below 95 per cent. so that after 3 hours on a warm, dry day all sporangia would have been killed. Under field conditions, therefore, very high humidity must continue for 8 hours in order to permit sporangium production; low temperature (optimum 13°) must follow to give the necessary stimulation for germination, and this must continue for at least one hour; thereafter swarming at 13° continues for about 30 minutes; at 16° for about 15 minutes; and at 21° for about 10 minutes before any

swarm spore has come to rest; when swarming has ceased the swarm spore germinates and within a period of 2 hours some germ tubes will have penetrated the cuticle and placed the fungus beyond the influence of external conditions. Totalling these respective minimum periods it is seen that relative humidity of 95 per cent. or above must continue for 11 or 12 hours in order to permit an infection and this only on the assumption that all other external conditions become operative at exactly the proper moment. These are minima and would apply therefore only to a small proportion of the lesions. After 8 hours of high humidity sporangia appear and continue to form until the leaf is consumed. Maximum sporangium production, therefore, could be expected only after 24, 36 or even 48 hours. Likewise, some germ tubes penetrate the leaf within 2 hours after the swarm spore ceases swarming but others are slower and some stragglers do not get through until a lapse of 10 or 12 hours. When all of these details are considered it is easier to see why the blight is more prevalent on lower shaded leaves and especially on those leaves which happen to lie in contact with moist earth. This stage of the blight is not commonly seen. When the disease is detectable from the car window it is usually the case that the tops are blighted because the fungus has moved from an infected basal leaf down the petiole and has girdled the stem.

#### SOIL RELATIONS

In a consideration of external factors affecting the relation between potato and parasite it must be borne in mind that the fungus is by no means confined to aerial parts but is in fact more commonly than otherwise subterranean. The fungus is commonly introduced into a field as mycelium in the seed piece. The spread of mycelium from the seed piece has been occasionally observed and recorded by several workers. It has remained for Miss de Bruyn, (3, 4) to correlate these fragments of evidence with her own work to establish unmistakably a saprophytic existence of the fungus in the soil.

*Soil temperature.* It is well known that the temperature of the surface layers of soil in a cultivated field follows rather closely that of the air temperature. At a depth of 4 to 6 inches, however, maximum temperature lags considerably behind air temperature with the result that the excessively high maxima of 40° sometimes recorded for air temperature never are approximated in the soil at the level at which the seed piece rests. An examination of thermograph records by W. H. Burkholder in a bean field at Perry in Western New York



covering the growing seasons 1916 to 1920 confirms the statement. In 1916, for example, maximum air temperature in the shade at foliage level on July 19 and 20 was 96° (35° C.) and 95° F. respectively, whereas at a depth of 5 to 6 inches the maximum soil temperatures for these days were 82° (28° C.) and 84° F. There were no other soil temperatures as high as 80° F. during the summer although on 4 successive days, Aug. 19 to 22, the maximum air temperatures were 95, 99, 98, 98° F. In 1917, soil temperature reached 83° and 85° F. on July 31 and Aug. 1; the air temperature exceeding 100° on each of these days. In 1918 there was a protracted period of warm weather in midsummer. Between July 20 and Aug. 25 the maximum air temperature exceeded 100° F. on 17 days. During the same period the maximum soil temperature reached 90° on Aug. 13; 87° on Aug. 6, 8 and 12; 86° on July 27, 29 and Aug. 25; 85° on July 26, Aug. 7 and 15; and was 80° or above nearly every other day. In 1919 the maxima of 84° F. were reached on 4 days and there were only 9 days throughout the summer when soil temperatures were 80° or above. In 1920 in very sharp contrast to 1918 the maximum soil temperature was 78° on Aug. 13 and there were only 13 days during the whole summer when the soil temperature, at 6 inches below the surface was above 70° F. It will be seen therefore that there was not a single day during the 5 years in which the soil temperature reached a critical temperature for the fungus and furthermore the temperature did not continue for many minutes at the maxima. The thermograph record for soil is a series of smooth waves with rounded crests and troughs, whereas for air it is a series of jagged waves with pointed crests and troughs, the latter often exceeding soil minima. It appears altogether probable, therefore, that the mycelium of the fungus in the soil rarely if ever is subjected to a critically high temperature in New York or New England potato fields. The probability is based on the fact that these records were taken in a region where the variety Green Mountain can not be grown with any assurance of success because of summer heat and that the season of 1918 is to the present time regarded as one of excessive heat.

*Soil moisture.* Moisture requirements of the fungus are not known. One may infer that the fungus is essentially aquatic in habit because it grows most vigorously in an area just beyond the visible margin of the lesion and because it grows more rapidly in growing tubers than in stored ones. Nevertheless the fungus will develop slightly on a fairly dry medium and one needs to know the tolerance of the organism for drought conditions. In fact, the whole subterranean existence of

the organism is a subject which needs extensive study. The following observations indicate the importance of such a study as something fundamental to a better understanding of the spread of the disease.

#### SPREAD OF BLIGHT

*Subterranean spread of blight.* The obvious way for late blight to become widespread is to plant here and there in many fields throughout wide areas, tubers which have living mycelium in them. This is easily and commonly done, often unwittingly, following "rot years" but it has been presumed that following "no blight" years the tubers are free from the fungus. Clinton's observations (5) already referred to, have stood for nearly 30 years without any modification by him or by numerous other investigators in North America. The number of cases recorded in which the fungus has passed directly from a diseased seed piece to the growing shoot is so small that this method of accounting for the appearance of the organism on aerial parts affords a wholly inadequate explanation of observed facts and does not help at all in an understanding of the appearance of blight following "no blight" years. The observations of Brooks (2), however, that stem lesions as well as lesions on newly-formed tubers had occurred on plants which were wholly free from leaf infection, show definitely that the fungus may perpetuate itself by entirely subterranean existence. Brooks' observations have been confirmed by Murphy and M'Kay (16). The total number of observed cases is small. The following observations, although not made under the rigid control of these earlier investigations, not only support the conclusion that direct infection of new tubers from diseased seed pieces occurs, but also suggest that the phenomenon is of sufficiently frequent occurrence to explain adequately the widespread occurrence of blight following a "no blight" year. Such general information as is available concerning the character of the growing season is added because of its bearing on the persistence of the fungus in the soil under relatively adverse conditions.

In the spring of 1930 tubers of Russet Rural and Rural New Yorker which appeared to be perfectly healthy were planted in 2 fields about 50 miles north of Ithaca. Mean summer temperatures were slightly below average for July ( $-2^{\circ}$ ) and August ( $-1.1^{\circ}$ ) and above average for September ( $+2.6^{\circ}$ ). July had 0.21 inches more rain than average, August had 1.1 inches deficiency and September was short 0.99 inches. Foliage blight could not be found in either field at any time. The search for the disease was no mere cursory

inspection but rather a systematic search plant by plant and leaf by leaf by one thoroughly familiar with the disease. At Ithaca it was impossible to establish blight in an experimental field although repeated attempts were made by applying swarm spores in water suspension. It is very unlikely that there was any foliage blight in the two fields mentioned because the drought seemed to be more severe in that neighborhood than at Ithaca. Nevertheless some blighted tubers were found in the storage bins and the fungus was cultivated from one of these. Tubers for planting in 1931 were taken from these bins. The growing season was warmer than average (July,  $+4.1^{\circ}$ ; August,  $+2^{\circ}$ ; September,  $+6.2^{\circ}$ ) and the rainfall less than average (July,  $-0.81$  inches; August,  $-2.08$ ; September,  $-0.07$ ). On September 27, 1931, foliage blight was found in the 2 fields but only after very careful search. The lesions were confined to leaves that were in direct contact with the soil. Occasional diseased tubers were found in the resulting crop although not more than 3 or 4 in a bushel. Tubers for the 1932 crop were taken at random from the storage bin and it is unlikely that any sorting for blight was done. Both fields were isolated from neighboring potato fields and neither field had been cropped with potatoes for at least 12 years. The growing season was about average although there were fewer periods of continued high maximum temperatures. The mean temperature varied from average as follows: July,  $-1.6^{\circ}$ ; August,  $+2^{\circ}$ ; and September,  $+1^{\circ}$ . Precipitation varied as follows: July,  $+0.29$  in.; August,  $-0.77$  in.; and September,  $-1.89$  in. Conditions were not favorable for an outbreak of late blight and none occurred in this general area. Blight lesions were found on occasional leaves in both fields but only after a most painstaking search and then only on lower leaves in contact with the soil. In the resulting crop, however, 9 to 15 affected tubers were found in each bushel. The dry weather in September prevented any spread of the disease on foliage and it is likewise very doubtful whether conditions were favorable at any time for tuber infection from spores produced on the prostrate leaves.

In corroboration of the above, a similar circumstance occurred in an adjoining county (Monroe). In May 1932, County Agricultural Agent R. C. Palmer sent some rotted tubers to M. F. Barrus for examination. The disease was diagnosed as blight rot. Mr. Palmer immediately questioned the diagnosis because of the total absence of foliage blight in 1931, a condition which had been established by Palmer and Barrus by extensive search in many fields. Fortunately slices were held in a moist chamber until the fungus fruited and

could be identified with certainty. It was, without question, *Phytophthora infestans*.

Stewart *et al* (20) stated that in 1910, farmers of western New York were not troubled with foliage blight but at harvest, and later in storage found many rotten potatoes infected with *P. infestans*. Their assumption is that foliage blight appeared very late in the season and was not distinguished from the natural death of the plants for they say: "When weather conditions are exceptionally favorable for rot, as they were last fall, a very little blight may result in a large amount of rot." While their assumption may be perfectly correct, it is likewise fair to assume that the farmers were right and that there was no foliage blight. The tubers which were rotted at harvest may have become diseased by direct infection from mycelium in the soil while the rot that appeared in storage could have arisen from infection at the time of digging.

*Spread of foliage blight.* Stewart *et al* (21) reporting observations at Geneva state that blight was entirely absent in certain years but nevertheless prevalent the following year. The experimental plots at Geneva were small and were under almost daily observation. If any foliage blight had been present it would almost certainly have been noted. Tubers harvested from the experimental plots were used for planting the succeeding crop. If blight appeared in the new crop it must be assumed that some of the tubers had become infected the previous autumn without the intervention of foliage blight or else viable sporangia were carried in from neighboring fields. The latter explanation is not very satisfactory, because the neighboring crops of the previous season were likewise produced under conditions unfavorable for the development of blight on the foliage. The assumption just made is based on the fact that thus far overwintering of the fungus, either in the vegetative or resting spore condition has never been established. All of the evidence is negative.

It has always been difficult to understand how it is possible for late blight to become prevalent in widely separated potato areas almost as soon as suitable conditions prevail. Migration from the south is practically precluded not only because of intervening areas in which few potatoes are grown, but especially because of the time element. Potatoes on Long Island have died naturally two to four weeks before blight can be found in the St. Lawrence valley. Furthermore, sporangia of the late blight fungus are so sensitive to drying that the few hours necessary for air currents to carry them from Long Island to Lake Champlain or even for a distance of 100 miles would be long enough

to kill all of them. If the sporangia were carried by the cyclonic storms, suitable humidity conditions might prevail at times but in such an event the spread would have to be from west to east. It is well known that Minnesota, Wisconsin and Michigan potatoes may be free from blight when the disease is prevalent in New York, and New England and *vice versa*.

Finally, the natural spread of *Phytophthora infestans* has been observed to be extremely limited and not rapid. In early October, 1929 the writers went to a potato field on a mountain top not far from Ithaca. All the potatoes in the valleys for miles about had been frozen on September 19 and were dead. The low temperature followed heavy rain. On the mountain top the potatoes were still green and growing. In looking down across a field of perhaps 50 acres there were observed here and there certain nearly circular areas which were noticeable because of a somewhat different color from that of the field in general. These areas were roughly 30-50 feet in diameter and upon inspection were found to be caused by the prevalence of blight. On the perimeter of such an area blight lesions were young. As one approached the center of the area, lesions of two and three ages could be found and it was even possible in some instances to find the individual plant on which the first lesion probably appeared. Unfortunately the seed piece and surrounding soil of these plants were not examined. The blight could not be found outside these areas. It seems perfectly clear that in the course of about 2 weeks the disease had spread naturally for a distance of from 15 to 25 feet with three, or perhaps four, chances for new infections to occur.

This evidence on natural spread of blight is strongly supported by the conclusions of Pethybridge *et al.* (18), drawn from a summarization of surveys on the incidence of potato blight in England. Their conclusion is: "The data on outbreaks of potato blight during the quinquennial period under review summarized above confirm the view expressed in the previous report . . . namely, that this disease does not start in the west and advance in wave-like fashion east and north in this country, as is sometimes imagined, but breaks out at various independent centres at considerable distances from one another, and often at approximately the same time."

#### SUMMARY

1. The susceptibility of the potato plant to attacks of *Phytophthora infestans* is not known to be altered by variability of weather conditions encountered during the growing period.



2. The most important external factors in the rapid spread of potato late blight are temperature and humidity.

3. A relative humidity of 95 per cent. or above must be maintained for about 8 hours to permit the production of a germinable sporangium. Liquid water in the form of rain or dew must be present to permit germination, swarming, and infection. Chilling is necessary to stimulate germination of sporangia. When external factors become effective at exactly the proper moment for optimum development of the parasite a very high humidity must persist for a minimum of 11 or 12 hours to permit infection.

4. In seasons when foliage blight is negligible or absent, tuber rot may occur in isolated hills by direct infection of new tubers from mycelium which has grown out into the soil from an affected seed piece. Such affected tubers perpetuate the parasite and make it possible to understand how it is that blight may be widespread following a year of little or no foliage blight.

5. The spread of late blight from a given centre is so slow and the sensitiveness of the sporangia of the parasite to drying is so great, that the appearance of the disease in widely separated areas at about the same time cannot be explained on the basis of migration of the parasite from one area to another.

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## COMMERCIAL FERTILIZERS FOR POTATOES IN THE KANSAS RIVER VALLEY

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The value of commercial fertilizers for the production of potatoes has been tested on the farms of the Kansas River Valley potato growers for the four-year period, 1931 to 1934. These experiments were conducted by the Kansas Agricultural Experiment Station with the coöperation of the American Cyanamid Company, potato growers and county agricultural agents. The tests were located in commercial potato fields on sandy loam, fine sandy loam, silt loam and clay loam soils. The response to treatment was similar on sandy and heavier soils. The tubers were planted with an Aspinwall planter having a fertilizer attachment. The fertilizer was deposited in bands on each side of the seed piece approximately two inches from and slightly below the level of the seed piece.

Climatic factors including amount and distribution of rainfall and

occurrence of extreme temperatures often influence the yield of potatoes more than soil nutrients. These climatic factors caused a great variation in the yield of potatoes during the four-year period of testing. This period, therefore, afforded an opportunity to study the results secured in a year of high yield, 1932; one of medium yield, 1931; and two years of low yields, 1933 and 1934. The four years during which this work was conducted represent the variation in climatic conditions which might be expected in the Kansas River Valley. The 1931 yield in the valley equaled the 15-year average; the 1932 yield was above average; the 1933 yield below average; and the 1934 yield extremely low.

The yield of graded potatoes produced with fertilizer treatments, as indicated, is given in table 1.

TABLE 1. *Yield of graded potatoes produced with fertilizer treatments as indicated:*

Plot No.	Pounds of Fertilizer Applied per Acre	Analysis of Fertilizer (a)	Yield in Pounds per Acre					
			1931	1932	1933	1934	Ave. 1931-'34	Ave. 1932-'34
1	107	21-0-0	.....	20,707	6,133	4,414	.....	10,418
2	100	0-44-0	.....	20,966	6,150	4,390	.....	10,502
3	No treatment	.....	9,995	20,727	6,130	4,022	10,219	10,293
4	190	12-24-12	13,024	22,876	6,980	4,685	11,891	11,514
5	150	15-30-0	12,878	21,537	6,890	5,152	11,614	11,193
6	No treatment	.....	9,921	19,509	5,757	4,082	9,817	9,783
7	200	11-48-0	13,709	21,976	6,933	4,181	11,700	11,030
8	400	11-48-0	.....	22,946	6,727	4,353	.....	11,342

(a) The first figure represents the percentage of nitrogen, the second the percentage of available phosphoric acid ( $P_2O_5$ ); and the third the percentage of water soluble potash ( $K_2O$ ).

The profit or loss due to the use of fertilizers of various analyses is given in table 2. The rate of application is indicated in the left-hand column. The cost of fertilizer was calculated on the basis of current prices in ton lots, f. o. b. Kansas City, Missouri, on Topeka, Kansas. The cost of picking, grading, sacking and hauling the increased yield of the fertilized plot over that of the unfertilized is calculated at 17½ cents per hundred pounds. The value of the increased yield is calculated at 75 cents per hundred.

TABLE 2. *Profit or loss due to use of commercial fertilizer calculated on basis of increased yield given in table III:*

Plot No.	Lbs. of Fertilizer Applied per Acre	Analysis of Fertilizer (a)	Cost of Fertilizer per Acre	Profit or Loss (-) per A. for Each Treatment					
				1931	1932	1933	1934	Ave. 1931-'34	Ave. 1932-'34
1	107	21-0-0	\$ 2.14	\$ ....	\$-2.29	\$-2.12	\$-0.23	\$ ...	\$-1.53
2	100	0-44-0	2.75	....	-1.38	-2.64	-0.98	...	-1.66
4	190	12-24-12	5.17	12.25	7.19	-2.03	-1.71	4.37	1.74
5	150	15-30-0	4.11	12.90	7.55	2.41	2.39	6.31	4.12
7	200	11-48-0	6.13	15.65	8.05	0.63	-5.22	4.79	1.15
8	400	11-48-0	12.26	....	7.51	-6.68	-10.36	...	-3.18

(a) The first figure represents the percentage of nitrogen, the second the percentage of available phosphoric acid ( $P_2O_5$ ); and the third the percentage of water soluble potash ( $K_2O$ ).

The plot which received 150 pounds per acre of fertilizer analyzing 15 per cent. nitrogen and 30 per cent. phosphoric acid ( $P_2O_5$ ) produced an increased yield over the nearest no treatment plot of 2,957 pounds per acre in 1931, 2,028 in 1932, 1,133 in 1933 and 1,130 pounds in 1934. The average annual increase for the four-year period was 1,812 pounds per acre. If the cost of the fertilizer in ton lots, f. o. b. Kansas City, plus the cost of handling the increased yield at 17½ cents per hundred is subtracted from the value of the increased yield at 75 cents per hundred, this fertilizer produced a net profit of \$12.90 per acre in 1931, \$7.55 in 1932, \$2.41 in 1933, \$2.39 in 1934, and an average annual net profit of \$6.31 over the four-year period.

The plot which received 200 pounds per acre of fertilizer analyzing 11 per cent. nitrogen and 48 per cent. phosphoric acid ( $P_2O_5$ ) produced a larger increase than the one described in the above paragraph in years of high yields, but not in years of low yields. This treatment produced a net profit of \$15.65 per acre in 1931, \$8.05 in 1932, \$0.63 in 1933 and a loss of \$5.22 per acre in 1934. The average annual net profit for the four-year period of this treatment was \$4.79 per acre.

Heavier applications of nitrogen and phosphorus than the two given above did not produce as large profit as did the lighter applications in any year. Nitrogen alone and phosphorus alone failed to produce enough increase to pay for the fertilizer each year. Potash used in combination with nitrogen and phosphorus produced a lower profit than the same combination of nitrogen and phosphorus. Results show that a medium heavy application of nitrogen and phosphorus is the best soil treatment for potatoes in this area.

## SECTIONAL NOTES

## CALIFORNIA

Potatoes in the Stockton District have not done so well as last year on account of weather conditions. California does not grow enough potatoes to affect price conditions materially. It is almost impossible to predict trend of prices until the crop is made in Colorado, Idaho, Oregon and Washington. Prices in California depend almost entirely on the quantity of potatoes shipped into the state from Idaho, Oregon and Washington. If these states would regulate the quantity that they ship into California, they could insure good prices for themselves.

The recently passed amendments to the Agricultural Adjustment Act provide the growers of potatoes with methods of regulating the quantities of potatoes that move in interstate commerce. Under these provisions, Colorado, Idaho, Washington, Oregon and California could join together and get a fair price on more than 50 per cent of all the potatoes sold by the group.

Minnesota, North Dakota, Nebraska, Wisconsin and Michigan could form another group and insure for themselves a fair price on approximately 75 per cent of all the potatoes sold by this group.

Maine, New York and Pennsylvania could join together and they would realize a fair price on 75 per cent of all the potatoes sold by the group.

However, if the three groups should work together under the A. A. A., by regulating the quantity moving in interstate commerce, a fair price on potatoes sold this season could be realized.

With the August estimate at 377 million bushels, prices in 1935-'36 will be as low as this years' prices. The outlook is for 20 to 25 cents a bushel in Maine, Michigan, Wisconsin, Minnesota, North Dakota, Nebraska, Idaho, Colorado, Oregon and Washington.

Prices in the deficiency producing states will be slightly higher but still below the cost of production

Potato growers have the legal means by which they can get 60 to 70 cents a bushel for every potato sold. As many will be sold at 60 to 70 cents as at 20 cents a bushel.

Even though the "Potato Act of 1935" is defeated the legal method of realizing a fair price every season is available to the grower whether a surplus or a shortage is produced. If there are not too many potatoes grown, control methods need not be used. If control methods are applied by October 1st, and this can be done,

every potato grower in the late states will get from two to three times as much money for his potato crop as he will if some action is not taken. (Aug. 12).—H. G. ZUCKERMAN.

## COLORADO

Over the state, in general, with the exception of the San Luis Valley, potato prospects declined slightly during July. Most districts have had no moisture since the heavy precipitation in May. Dry land fields are in the critical stage, and unless there is moisture within the next ten days, yields will be very low.

Psyllid yellows is showing up in most districts, but is nearly a month later than last year, and the infestation is not nearly so heavy. The damage will be slight compared with last year.

Growers in early sections are harvesting with yields about normal where potatoes were sprayed. Prices are low in spite of light carload shipments; most growers receiving from 65 to 85 cents per hundred, depending on their proximity to market. (Aug. 12).—C. H. METZGER.

## CONNECTICUT

Two weeks of wet weather during the latter part of July were favorable for the spread of late blight and, consequently, potatoes are badly infected on unsprayed or poorly sprayed fields. No doubt the yields will be much less than expected from such fields. However, dry weather and careful spraying have controlled the blight and there seems to be little danger now of a general epidemic.

On August 5, wholesale prices to farmers ranged from 50 to 75 cents a bushel at market centers. (Aug. 10).—B. A. BROWN.

## INDIANA

The condition of our potato crop is about normal. It stands approximately at 85 per cent, or about 15 to 20 points higher than last year. In some sections of the state, particularly in the southwestern part, where they had heavy rains in the early part of the growing season, the ground dried up considerably during the ripening process. With the extreme heat there was some loss in the early crop but not enough to do considerable damage.

The only trouble we have had so far with the late crop has been

a mild attack of the leafhopper. We have many fields that look very promising at this time, although we are in need of rain in the central and northern sections of the state.

The quality of this year's crop is much better than it has been during the past two or three years. Even those that come in from other localities are graded much better than they have in the past. Potatoes are retailing in the stores at from 60 to 75 cents a bushel. (Aug. 12). —W. B. WARD.

#### IOWA

A large part of the potatoes in this state are produced in the great number of patches of a half-acre and less by the general farmers, who number 200,000 and in the home gardens of the country towns. All these people have many more potatoes than they had last year.

Commercial producers have a slightly larger crop than last year, but only a fair one. Because of the fair supply of home-grown potatoes throughout the state, the commercial producers will not have the extraordinary carlot sale which they enjoyed last year, and most of the crop now seems likely to go out by freight to the St. Louis, Chicago, and Kansas City markets. It now appears that until the latter part of September, our commercial producers will have less competition on the nearby carlot markets than they had after the end of the truck sale of last season.

We have a large number of very small, weak plants this year and our first crop from northern seed shows a considerable amount of virous diseases. Our growers seem likely to make forward steps in their demands for very low virous content in the potatoes purchased from the North for growing their own first crop seed. It is possible also that next year, a larger proportion of our acreage will be planted with seed from the North, although when things work out well, we get our very largest crop from our own first-year seed. This is possible because of the fact that seed pieces from such seed show less decay than is found when most northern seed is planted.

I am sorry to say that our growers were in large measures opposed to the Warren-Smith bill. It is my own idea that potato growers of this region would do well to play the game with their brethren in other potato districts, even if, at the present time, they do not like the details of the measures proposed. (Aug. 10). C. L. FITCH.



## KENTUCKY

The associations are shipping in volume. Prices were maintained quite well until the week beginning August 4th, when a low of 85 cents per cwt. occurred. Potatoes moving out by truck command a slightly higher price. Growers about Lexington who have contracts with chain stores have been receiving \$1.00 per cwt. or slightly better.

Yields in the Louisville district are reported as high as 180 bushels per acre, but the average is below 150 bushels. Poor preparation of ground and late planting because of continued wet weather is reflected in spotty yields.

General conditions are better in the Lexington district. A few fields, which have been dugged to date, have yielded between 225-250 bushels per acre. This is particularly true of the early-planted potatoes. (Aug. 10).—JOHN S. GARDNER.

## MAINE

Weather for the past three weeks has been very warm and dry in decided contrast to conditions prevailing during June.

The most accurate indications we have at present of the effect of the continued drought are the yield tests made at the State Experimental Farm in Presque Isle, which for the week of August 12th, gave ten barrels less than that of a year ago. There is no apparent let-up in the drought.

Cobblers have passed by the time when moisture would be of great benefit. Fields have gone down very fast the past week, and while there is a fair crop for harvesting, due to their getting an earlier start than the late varieties, nevertheless yields will be cut considerably over those existing during the past year. Aphids are infesting fields now in great numbers, and these insects will also have an injurious effect on the crop.

Conservative opinion indicates prospects for reduction of yield from  $\frac{2}{3}$  to  $\frac{3}{4}$  of last season's crop.

While no figures are available on the acreage passing certification for the final inspection, the acreage rejected is greater than for many years. The chief difficulty has been with Spindle Tuber in Irish Cobblers, and Mosaic in Green Mountains. In spite of the increased entries, the greater number of rejections, plus estimated reductions in yield, will probably give no greater tonnage of certified seed than was available last year.

Prices offer very little encouragement. Nothing definite is available at present on the price levels our crop will seek during harvesting. There are now apparently very few markets open to us during September.

The production credit organization is proceeding rapidly with their plans, and probably their program of marketing security given for their loans is the most significant and constructive step ever taken in the Maine potato industry. It apparently has the support now of all elements in the deal and we are looking forward to marked success. (Aug. 15).—FRANK W. HUSSEY.

#### MASSACHUSETTS

The Cobbler crop is practically mature, the vines having gone down rather rapidly during the past two weeks. Digging is in progress, with sales at present ranging from 50 to 60 cents a bushel. The yield is about average.

While no late blight is yet apparent in most sections of the state on Green Mountains, evidence on the foliage has been present near the coast. Excessively muggy weather for a considerable period of time may lead to later trouble from this disease if the late crop is not adequately protected by spraying. Present indications show that we may have an average crop in this area.

Spray demonstrations conducted on both early and late varieties are demonstrating very conclusively the benefit from maximum applications of spray in protecting the foliage from insect infestation. (July 30).—RALPH W. DONALDSON.

#### MICHIGAN

The acreage this season is practically the same as that of last year. There has been some increase in acreage in the southern part of the state, particularly in localities near good markets. However, in the northern portions of the state, the acreage has been somewhat reduced. It is believed now that the total crop this year will be approximately 20 per cent lighter than it was last season and probably about 8 or 10 per cent above the 1928 to 1932 average crop. Most sections of the state have had ample rainfall during the growing season and the potato fields look quite well at this time. However, in the northern section of the Lower Peninsula, severe drought early in May followed by approximately ten days of rainy weather prevented early planting, so there are many fields that were planted the last week in

June and even the first week in July. Consequently a high percentage of fields show rather weak, poor stands at this writing.

In the Upper Peninsula, weather conditions have been quite favorable for the potato crop. A survey of that area during the past two weeks showed, generally, a wonderful growth of Green Mountains and Russet Rurals. The Green Mountain variety is grown more extensively in Marquette, Baraga, Houghton, and Gogebic Counties. The Russet Rural is confined pretty much to Luce, Menominee, and Iron Counties. Weather conditions in many northern sections have been very favorable for the development of late blight but no symptoms of this disease have been observed as yet. Growers, however, are being cautioned to maintain a thorough spraying program. One of the most serious and most general troubles this year is from insect injury. It seems that growers in most cases have been unable to kill potato bugs. Many fields have been considerably damaged by this pest.

Prices for potatoes in this section have been very discouraging to growers. In the Upper Peninsula, early potatoes were selling for approximately one dollar and twenty-five cents per bushel last week. In Lansing, local potatoes are bringing approximately eighty cents per bushel. The 1934-'35 seed potato crop netted the growers only thirty to thirty-five cents per bushel. The bulk of the certified seed crop moved for approximately sixty cents per bushel and many times during the shipping season ordinary table stock sold for only ten cents per bushel.

The total acreage listed this year for inspection is 1,900 compared with 2,937 listed in 1934. There are approximately 700 acres of the Russet Rural variety left, 200 Green Mountains, and about 40 acres of Irish Cobbler. The Katahdin acreage this year is 163 compared to 82 for last season. Certified fields in general, are showing very well at this time. The disease factor so far has not been serious.

Plans are being made for a potato field day at the Potato Experimental Farm, Lake City, on September 12th. Eight departments of the college will have exhibits emphasizing better cultural, grading, and marketing methods. Approximately 40 acres of potatoes are planted in demonstration and experimental plots. Seedlings and new varieties will constitute the major portion of the experimental work. Other experiments include irrigation, commercial fertilizers, date of planting, distance of spacing, and spraying tests. A very complete machinery exhibit is being planned in connection with field day. Several thousand growers are expected to attend this meeting. Out-of-state visitors are cordially invited to attend. (Aug. 12).—H. C. MOORE.

## NEBRASKA

The first of the early potatoes in the western irrigated districts were being harvested about August 12. The yield of all these early potatoes is being considerably reduced by psyllid damage. This pest has not yet become apparent to a great degree in the late crop. In some fields flea beetles have been quite numerous, and the Colorado potato beetles have been more numerous in western irrigated districts than they have been for many years. Because of these various insects it is likely that potato growers may have to resort to a regular program of spraying with lime-sulfur and arsenicals. Prospects are very good for the late irrigation crops.

In the late dry-land region the crop started off under better conditions than have prevailed for many years. Stands there are uniformly excellent. The continuously hot weather during the latter half of July and the first half of August checked the growth of the plants. Most moisture has been removed from the top two feet of soil and at this date plants are making little or no growth. Whether the crop will be only mediocre or quite good will depend upon any rainfall which may occur during the next few weeks. Slight psyllid damage has been observed in some dry land fields. (Aug. 12).—H. O. WERNER.

## NEW JERSEY

A large crop of excellent quality Irish Cobblers is now being harvested. Yields of more than 300 bushels an acre of graded potatoes are commonly reported from Central New Jersey. Harvesting operations are proceeding slowly to date, little more than thirty per cent of the crop being harvested. The Potato Sales Company was opened Aug. 9 with a greater part of the crop signed up to be sold through one office. The growers are receiving 60 cents a hundred for graded sacked potatoes at the farm. The dealers and growers, through the Central Office, are attempting to hold the present price but few sales are being made, due to the competition from other areas. In view of this fact it is very questionable, if the present price can be maintained. The present indications are that the harvesting season will be unusually long. (Aug. 16).—W. H. MARTIN.

## NEW YORK

To date this has been the worst season for yellow dwarf in New York State. The disease is still largely confined to certain areas in the southwestern part of the State. In the affected districts, it is not

only interfering with the certification of seed, but it is also doing some damage in table stock fields. Reports from growers indicate that a few fields show as high as 50 per cent in table stock. Late blight has been observed by members of the College Staff in Rensselaer county and is reported by a seed grower from Cortland county. Weather conditions have been favorable for an outbreak of this disease, and low prices and lack of working capital have induced the growers to neglect their usual spraying practices. (Aug. 10).—K. H. FERNOW.

Potato crop conditions are not so good as they were when the July report was made. The writer and Dr. Karl Fernow made a survey of approximately a hundred fields in eastern New York during the first week in August. Because of excessive rains, conditions in these sections are poorer than they have been for many years. Most fields are very weedy and wherever water could stand the plants are worthless. A trace of blight is showing at this early date and conditions appear to be ideal for its spread especially since less than the usual amount of spraying has been conducted. Inventory has been made of the damage done by the July floods in Steuben and Allegany Counties of western New York, these being important potato counties. It is estimated that growers in these counties will harvest not over 50 per cent of a normal crop. In central New York and the extreme western part of the state, potatoes look better than usual. Erie, Genesee and Monroe Counties, where rainfall is often deficient, have had more favorable growing conditions this year.

The total crop promises to be much shorter than normal, not because of acreage reduction but because of poor stands due to a cold, wet June and also on account of excessive rains and flood conditions in many potato counties. Long Island's crop was cut short by hot, dry weather in June and July, resulting in severe infestation of aphids. Growers recognize that the crop will be short and are now asking for all the information they can get on price prospects. After the disastrous prices of last season, they will hesitate to hold this year's crop even though short. It will be hard to hold the harvest in check if, and when, the market looks promising. Upstate growers do not feel that the provisions of the Warren Bill can be administered successfully, even if the bill passes Congress. There are too many small growers producing too many kinds of potatoes under all sorts of conditions and all kinds of marketing methods.

Under the joint auspices of the Empire State Potato Club and the State Farm Bureau Federation, committees of growers have been

set up to analyze and study the real problems of the New York potato industry. Each committee is headed by a prominent grower with the local county agricultural agent as secretary. Besides the executive committee, headed by Roy A. Porter of Elba, New York, the five committees appointed are (1) Tuber Quality, (2) Seed and Varieties, (3) Marketing, (4) Cultural Practices and (5) Utilization.

These committees will assemble information pertinent to their respective fields, analyze it, and suggest ways and means for further research and extension needed. This is a permanent set-up of committees to which problems, as they arise, can be submitted by growers. (Aug. 9).—E. V. HARDENBURG.

#### LONG ISLAND

Only a small part of the Cobbler crop has been moved because of low prices and a weak demand. At the present time, growers are receiving 30 cents per bushel for No. 1's, which is approximately one-half the cost of production. Digging and hauling are being regulated by a grower-dealer committee. This committee also sets the minimum price (in accord with market conditions) to be paid growers. While this committee has not received 100 per cent cooperation from growers and dealers, its work has been of considerable benefit. The Cobbler crop has never been of finer quality but yields are not so large as last season. No Green Mountains have been dug as yet, so we do not know what the crop will be. The general prediction is, however, that the Green Mountain crop will be about an average one. (Aug. 16).—W. G. BEEN.

#### OHIO

The marketing of the early potato crop in the Ohio River district is completed. Two counties, Washington and Hamilton, packed and marketed their crop cooperatively. The average price in Washington County for the week ending July 13 was \$1.22½ per cwt. The price dropped to \$1.10 per cwt. the week ending July 27 when the marketing was completed.

The Cobbler crop is now being harvested on the muck soils and in northern Ohio. Prices generally are \$1.00 per cwt. with a few choice lots bringing a few cents more.

The late crop was above normal until unprecedented rains the last two weeks materially damaged it. These rains and floods covered central and northeastern Ohio. Flood waters were higher than they



have been since 1913. Many fields were covered with water while many others were damaged by washing.

Early blight is spreading and the leafhopper population is greater than it has been in several years. (Aug. 14).—E. B. TUSSING.

#### PENNSYLVANIA

The early potato crop, where well tended, seems to be good. The late crop has made tremendous vine growth due to ample moisture through July. As might be expected, with excess moisture, late blight has appeared in many sections. In Cambria and Somerset, blight is reported to have killed many fields. Spraying this year seems much below par in acreage and intensity.

Growers are, of course, discouraged by prospects of another low price year, but a large crowd attended the potato field day on July 31 at the Norristown State Hospital. They found the early crop fairly well matured and a very fair yield. The late crop had suffered from typical flood and heat conditions; weed control had been impossible. The constructive thoughts expressed in the talks by State Secretary of Agriculture, Hansel French, and Miles Horst, Secretary of the State Potato Association, were those of placing better graded potatoes on the market and cooperation aimed at the capture of our local markets. (Aug. 12).—J. B. R. DICKEY.

Generally speaking, there has been an abundance of moisture throughout the State. In several small sections, however, the potato crop has suffered from lack of moisture. The early crop in these sections is turning out very poorly. Where rain was plentiful the yields are running as high as 300 to 400 bushels to the acre.

Late blight has become quite general in the late Rurals in the mountain counties. Several fields have already been refused certification because of heavy infection. Where spraying is thorough, the growers are experiencing no difficulty in holding the blight under control.

Growers are receiving 45 to 50 cents a bushel for most of their crop although some are being moved at 40 cents a bushel. (Aug. 15).—K. W. LAUER.

#### RHODE ISLAND

Cobblers are now being harvested with yields of 300 to 350 bushels reported. Prices are lower than they have been for many years, with growers receiving from 75 to 90 cents per 100 pounds. Some

late blight is reported, but Green Mountains are looking good. (Aug. 16).—T. E. ODLAND.

#### VERMONT

Excessively wet ground and extremely warm weather between rains in July appear definitely to have hurt yield prospects in Vermont this year. Scattering stands with many dwarfed plants are common to most of the small, home-use fields along the roads.

Since fields of this type are very largely grown for the growers' own use—a considerable drop-off in production would seem to be indicated.

Conditions are naturally better in the larger commercial fields and those enrolled for certification, but in many of these there are wet spots with poor stands. The set of tubers is generally reported as rather small.

Hopperburn is apparent to a considerable extent in many fields, but, to date, no late blight has been noted.

Not enough potatoes have been dug in Vermont at this date to establish price quotations.

Full enrollment for certification now totals about 575 acres and approximately 100 growers. In addition, some 12 or 15 growers, representing about 75 acres, entered through the Central Test Plot, but withdrew for reasons of poor stand or excess of diseases.

Comparatively little Mosaic has appeared in seed fields notwithstanding ideal conditions for bringing it out. (Aug. 12).—H. L. BAILEY.

#### WASHINGTON

Inspections of certified seed potatoes in the northwestern part of Washington show an unprecedented amount of leaf roll and mosaic. In fact, we have already found it necessary to disqualify a number of fields of growers who have been growing satisfactory stock for several years. One of our men has just reported from the eastern part of the state, and states that conditions are about normal in that district. However, since the larger tonnage of certified seed is produced west of the Cascades, it appears likely now that our supply of certified seed will be distinctly below normal next spring.

Commercial potatoes are almost a drag on the market at the present time. Last week we had reports of sales by growers as low as \$12.00 per ton. (Aug. 12).—CHAS. D. GAINES.

## WISCONSIN

A recent check up on conditions in Wisconsin would indicate that there is a general trend toward a much more reduced crop than indicated in our last report. Although rainfall has been quite generally adequate there have been some other conditions to cause a reduction in yield from that which was estimated earlier.

In many of the diversified farming areas grain and hay crops have been very heavy. We find in these general farming sections that the wet weather has interfered with hay and harvesting operations and as a result there has been considerable neglect of potatoes. We have not, for several years, noted so much injury from the potato beetle, flea beetle, leafhopper, and injury resulting from the infestation of weeds. We believe, however, that these conditions will be an important factor in crop reduction.

In some of the specialized potato growing areas where better care has been given the crop, fields are in unusually fine condition and we expect some excellent results in yield and quality.

The earlier crop is much shorter than previously estimated due to a week of extremely warm weather immediately following a period of heavy rains.

This is proving an excellent year in Wisconsin to conduct seed improvement work. Conditions have generally favored the expression of degeneration diseases and therefore the season has offered unusually favorable opportunity for the location of the better strains of seed potato stocks. (Aug. 14).—J. G. MILWARD.

## CANADA

There is slightly over thirty per cent reduction in acreage entered for inspection in 1935, as compared with 1934. Approximately 20,000 acres are listed, compared with 28,810 last year. The acreage by varieties entered are,—Irish Cobblers, 9,789; Green Mountains 6,372; Bliss Triumph 1,151; Rural New Yorker 823; Netted Gem 296; Early Ohio 200; and other varieties approximately 1,400 acres, including 83 acres of Katahdin.

Growing conditions have been generally good with plenty of moisture in most districts and the seed crop is doing well. Some reports of a considerable amount of missing hills in the commercial crop due to wet weather at planting time, have been received from the Maritime Provinces. The St. John's valley crop situation has been reported as only "fair" at this date.

Prince Edward Island has slightly over 11,500 acres listed for inspection for seed purposes and New Brunswick just over 3,000 acres. (July 31).—JOHN TUCKER.

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### POTATO MEETINGS

August 29—Coudersport Penna. Potato Field Day.

September 12—Lake City, Michigan. Potato Field Day.

October 21—Wausaukee, Wisconsin. Annual Meeting and Show, Wisconsin Potato Growers' Association.

November 5-8—North Judson, Indiana. Sixth Annual Truck Crops Show.

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### REFERENCES

Dr. Wm. H. Martin—N. J. Plant Pathologist, N. J. Agricultural College, New Brunswick.

Paul B. Mott—Inspector, State Department of Agriculture, Trenton.

Geo. I. Ball—County Agricultural Agent, Salem.

F. A. Raymaley—County Agricultural Agent, Bridgeton.

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## THE ST. LOUIS MEETING

The next annual meeting of the Potato Association of America will be held at St. Louis from December 31 to January 2, inclusive. The Hotel Jefferson has been designated as the official headquarters. This hotel will also be the headquarters of the A. A. A. and the American Society of Agronomy. The Statler will serve as headquarters for the American Phytopathological Society and the American Society for Horticultural Science.

It is anticipated that there will be a larger representation from the Western and Southern states at this meeting than has been the case for several years. In view of this fact, an effort is being made to prepare a program which will be of special interest to workers from these sections. A session is being contemplated to discuss certified seed potatoes from the standpoint of the northern producers as well as the southern buyers. A joint session has been arranged with the American Phytopathological Society for Thursday, January 2. At this session it is planned to discuss the advancements in our knowledge of breeding for disease resistance and also the recent developments in the control of seed and soil borne scab and rhizoctonia. At other sessions consideration will be given to psyllid yellows, "hay-wire", dry-land farming, storage problems, etc. A joint session has been arranged with the American Society for Horticultural Science on the afternoon of December 31. It has been suggested that some time should be devoted to a discussion of the Potato Control Act since this is probably the most important question facing the potato grower at the present time. It has also been suggested that consideration be given to ways and means of improving marketing conditions.

The titles of papers to be presented at the meeting should be sent to the Secretary-Treasurer in the near future. This is important since the program must be completed early in November. While titles only are to be submitted at this time it should be recalled that the papers presented at St. Louis will be published in the American Potato Journal next year.